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Olivia Ellis
Yale University, microlabrat@aol.com

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EPIDEMIOLOGY AND TRENDS FOR VIBRIOSIS IN CONNECTICUT, 1999-2010

BY

Olivia L. Ellis

Thesis for submission to the Yale School of Public Health for the requirement of the Degree of Master of Public Health

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ABSTRACT

Background: Behavior and environment play a significant role in the acquisition of vibriosis. *Vibrio* data collected over the past twelve years suggests that incidence of vibriosis has increased in Connecticut. Vibriosis is a physician and laboratory reportable illness in Connecticut. Surveillance data was collected by Connecticut FoodNet and Connecticut Department of Public Health staff. These data were analyzed to evaluate the epidemiology and trends in incidence over time.

Methods: Incidence rates were stratified by demographic, geographic, bacteriologic and clinical groups and trends in the incidence and percentage of cases in these groups were analyzed over time. Because risk factors for developing vibriosis could be dependent on specific behaviors, trends in the percentage of cases with selected exposures were also analyzed over the twelve year time period.

Results: The incidence of vibriosis increased over the past twelve years in Connecticut, from an incidence of 1.83 per million population in 1999 to 8.95 in 2010. Incidence rates were highest among men, during the summer and fall months, in those over the age of 50 years, and in people who reside in coastal counties. While increases in incidence rate/number of cases were seen for most demographic, geographic, bacteriologic, and clinical and exposure groups, only the percentages of all case-patients who had wound infections and had direct skin and wound exposure to water increased over time.

Conclusions: Possible explanations for the overall increase include: warmer water temperatures with higher *Vibrio* levels and/or more people spending more time in contact with potentially contaminated water, especially the elderly. The faster relative increase in wound infections and relative increase exposures involving skin, merit particular study to determine factors for their faster increase and monitoring to see if they continue to cause an increasing proportion of all cases.

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INTRODUCTION

Vibrio is a genus of comma shaped, Gram negative, oxidase positive bacteria in the family *Vibrionaceae.* This bacterial genus is commonly found in warm, brackish water of marine estuaries. *Vibrio* species are one of 31 major known foodborne pathogens in the United States [1]. Human vibriosis is caused by infection with any of at least 12 species in the genus *Vibrio* [2]. Vibriosis is associated with three major syndromes that cause illness in humans including: gastroenteritis, wound infections, and septicemia. It was just five years ago, in 2007, that human vibriosis (non-Cholera *Vibrio* species) became a nationally notifiable disease in the United States [3]. Consumption of raw or contaminated shellfish has been identified as a major source of these infections [4]. *Vibrio parahaemolyticus* is the leading cause of food poisoning caused by consumption of contaminated seafood, especially raw oysters, worldwide [5]. Additionally, *V. parahaemolyticus* is the most common cause of seafood-associated gastroenteritis in the United States [4]. Other risk factors for acquiring vibriosis, besides shellfish consumption are wading or swimming in brackish water, wound exposure in water or unintentional ingestion of contaminated water in marine environments. In addition to these behavioral risk factors, certain underlying conditions such as old age, liver disease, and diabetes can predispose individuals to illness caused by *Vibrio* [6].

The true burden of most vibriosis infection is difficult to estimate due to the fact that most infections require laboratory confirmation, and many of those affected may not seek medical treatment for their ailments. However, laboratory-confirmed cases do represent a portion of infections within a community; and for this reason, stable surveillance systems offer an estimate of the current trends in of *Vibrio* infection within the population.

Vibrio species cause an estimated 8,000 infections per year in the United States [7]. There were a total of 160 case-patients with *Vibrio* spp. (annual incidence 0.35 per 100,000 or 3.5 per million population) reported at the ten national FoodNet sites in 2009 [8]. Species information was available for 154 *Vibrio* spp. infections and the most commonly reported species were *V. parahaemolyticus* (52%, 80/154) and (14%, 22/154) were *V. vulnificus* or *V. alginolyticus.* The estimated incidence increased (85%, 95% CI=36%-150%) for vibriosis in 2009 when compared to data from 1996-1998 [8]. This increasing trend has continued since 2002 [8].

In 2010, the ten national FoodNet sites reported 193 case-patients with *Vibrio* infections (annual incidence 0.4 per 100,000 or 4.0 per million population) [9]. Among the 186 *Vibrio* nationally reported specimens with species information in 2010, the most common were *V. parahaemolyticus* (57%) and *V. vulnificus* (13%) [9]. Between the years 1996-2010, the rate of nationally laboratory-confirmed vibriosis cases increased [9]. Additionally, overall national incidence of vibriosis in 2010 increased when compared against rates from years 1996-1998 and the years 2006-2008 [9]. Compared to data from 1996-1998, the estimated incidence for 2010 increased (115%, 95% CI=60%-187%) [9]. In 2011, Scallan, et. al. estimated national rates of hospitalization for toxigenic *V. cholerae*, *V. vulnificus*, *V. parahaemolyticus*, and other *Vibrio* spp. [1]. Additionally, death rates were estimated for toxigenic *V. cholerae, V. vulnificus*, *V. parahaemolyticus*, and other *Vibrio* spp. [1]. While these mortality rates are useful for understanding *Vibrio*-specific disease severity, the reported FoodNet incidence rates are only indirectly derived estimates of the true burden of vibriosis and do not shed light on trends in Connecticut.

Over the past twelve years, there has been a progressive increase in the number of incident *Vibrio* cases in Connecticut. Although *Vibrio* infections may be less common than other

foodborne illnesses under national surveillance, *Vibrio* infections are increasing [9] and vibriosis incidence in the United States remains higher than the Healthy People Food Safety Goal of 0.2 cases per 100,000 (or 2 cases per million population) that is set for 2020 [9].

The most successful public health interventions are dependent upon complete assessment and accurate knowledge of the risk factors that are associated with a particular illness. Therefore, understanding the epidemiology of *Vibrio* infections will assist public health professionals at targeting prevention and intervention efforts to reduce *Vibrio* incidence in Connecticut and across the United States. Vibriosis is an important national public health problem because these infections have the potential to be associated with severe morbidity and mortality. Furthermore, these infections are important because changes in their incidence could hypothetically result from the impacts of climate change including warming seawater. Previous studies have established an association between warmer water temperatures and the presence of *Vibrio* [4]. Thus, sea surface temperatures may be an important determinant of risk associated with acquiring vibriosis.

This thesis presents an analysis of the epidemiology and trends in vibriosis in Connecticut over twelve years and a comparative observational trend analysis of clinical data collected through routine surveillance efforts. The objective herein is to describe the frequency of *Vibrio* infections in Connecticut, describe the trends in incidence of *Vibrio* over the past twelve years of active surveillance in Connecticut, to describe the clinical and epidemiological attributes of *Vibrio* infection, and to make recommendations based on these findings.

METHODS

Study Design

In Connecticut, vibriosis has been both a physician and laboratory reportable infectious disease since 1999. In addition to these reporting requirements, Connecticut participates in the Emerging Infections Program's FoodNet project (FN-CT), which conducts statewide laboratory-based active surveillance for vibriosis in cooperation with the Connecticut Department of Public Health (DPH), the Centers for Disease Control and Prevention (CDC), and the Yale School of Public Health. The FN-CT site was one of the first in the United States, initiated in 1996, and demographic information was collected from case report forms for all culture-confirmed *Vibrio* infections between the years 1996 and 2010. However, vibriosis data was initially collected only in two counties (New Haven and Hartford), until 1999, when all *Vibrio* isolates (statewide) were required to be submitted to the state public health laboratory for confirmatory testing. Therefore, this study utilizes FN-CT surveillance data between the years 1999-2010. Only incident cases reported between 1999 and 2010 were included in this analysis in order to determine trends associated with incidence over time. To verify completeness of reporting, all in-state hospital and reference laboratories were routinely audited as part of FN-CT surveillance.

Every attempt was made by local health or DPH staff to interview all culture-confirmed cases via telephone in order to complete the CDC's, "Cholera and Other Vibrio Illness Surveillance Report" (COVIS) form. The data collected on this report includes clinical data, information about underlying illnesses, history of seafood consumption, and potential exposures during the seven days prior to illness onset. Upon completion, COVIS reports are sent to the CDC and entered into a national database.

Laboratory Methods

Vibrios are not easily identified on routine enteric media because *Vibrio* species emulate normal enteric flora and appear as lactose fermenting colonies on MacConkey agar. Therefore, laboratory-confirmed and suspected cases of *Vibrio* must be submitted to the DPH Laboratory for confirmatory testing and species identification on the selective media thiosulfate citrate bile salts sucrose (TCBS), sulfide indole motility (SIM), lysine iron agar slant (LIA), motility indole ornithine (MIO), and triple sugar iron agar (TSI), 0%, 1%, 3%, 6% , and 8% salts. If the organism is oxidase positive from a blood agar plate then it is subcultured to an API strip for species identification.

Statistical Methods

Yearly incidence rates were calculated using the 2000 United States Census Bureau population estimates or mid-year population estimates from DPH [9]. Yearly incidence rates were tested for trend and data were compared by strata defined by age, sex, race, source, county, percentage of people with a given syndrome (gastrointestinal, wound, septicemia), risk factors, and season using the chi-square test.

Analyses were performed using SAS version 9.2 (SAS Institute), EpiInfo version 6.0 (CDC), and Microsoft Excel. A number of variables were analyzed for trends over the twelve-year period via the chi-square test for trend using mid-year population estimates and the United States Census population information for the individual years 2000 and 2010. Data were examined for significance in trend by chi-square over four three-year intervals (1999-2001, 2002-2004, 2005-2007, 2008-2010).The mid-year population estimates were used for trends analyzed over these time intervals, except in the case of 1999-2001, which had a mid-year

population during a national census year. Excel was used to assess the association between incidence rates and time in years for each individual year.

RESULTS

From January 1, 1999 through December 31, 2010, 174 incident cases of vibriosis were reported to DPH. The incidence for vibriosis over the twelve-year period under analysis was 4.26 per million person-years. Table 1 shows the distribution of the dataset by age, sex, race, ethnicity, source, hospitalization, county, season, and year. The most distinct finding was a progressive increase in incidence by year, with incidence climbing from 1.83 per million population in 1999 to 8.95 per million population in 2010. The incidence of *Vibrio* also varied significantly by age and was most common in individuals over 50 years of age (8.03 per million person-years). In addition to this finding, adults in the 20-49 year age group and the 50 and older age group were respectively 2.46 and 5.63 times more likely to be infected with *Vibrio* than their younger referent counterparts, aged 10-19. *Vibrio* in Connecticut had a significantly higher incidence in men (5.81 per million person years) than in women (2.80 per million person years) ($p \leq 0.0001$), with male cases accounting for 66% of all *Vibrio* infections whereas women only accounted for 34%.

Incidence rates by race/ethnicity were not calculated due to a large proportion of missing data (24%). Whites accounted for 71% (124/174) of the total cases reported. Of the cases with a known ethnicity, 90% (103/115) were non-Hispanic. Overall, 52% of the cases were diagnosed based on stool isolates and about 29% were diagnosed based on isolates from wounds. Relatively few cases (9%, n=15) were diagnosed based on positive blood cultures. Most, 79%, individuals received care in an outpatient setting while 21% were hospitalized for their illness. The survival outcome for 5 patients was unknown or lost-to-follow-up and 2 patients died. The incidence of vibriosis was highest in the coastal counties of Middlesex (6.99 per million person-years) and Fairfield (5.95 per million person-years) and lowest in the inland, non-coastal counties of

Windham (3.06 per million person-years) and Hartford (2.33 per million person-years) for the twelve years under study. The majority of all cases occurred in the months of July-September (72%). Overall, 86% of vibriosis occurred during summer and fall (warm water season) as opposed to winter and spring (14%, cold water season).

Because *Vibrio* incidence increased over time, we examined a number of variables to see if trends increased for all demographic, geographic and diagnosis site subgroups. In general, vibriosis increased for all groups, but more significantly for some (ages 0-19 and $\geq$ 50 years, coastal residence, and wound source of infection) (Table 2). *Vibrio* cases in children 0-19 years had an 8-fold increase, people age 50 and over had a 4.4-fold increase in cases, vibriosis cases in coastal residents accounted for a 4.36-fold increase, and wounds accounted for a 5.42-fold increase in *Vibrio* cases compared to an overall 3.37-fold increase in *Vibrio* when comparing incidence from 1999-2001 to incidence in 2008-2010.

Clinical and risk factor information was available for 166 patients who were interviewed with a COVIS report form. The most common exposures amongst those with vibriosis included consumption of any seafood (57%), consumption of raw seafood (34%), swimming (26%), and walking in water (17%), and wound exposures in water (14%). We examined whether infection site and any of the exposures became more common over time (Table 3). Although a number of exposures appeared to increase over time, only the percent wound infections and percent of people with wound exposure in water increased at statistically significant levels ($p=0.02$ and $p=0.007$, respectively).

The majority (81%, 46/57) of persons with raw seafood exposures were diagnosed based on stool culture. The remaining persons with raw seafood exposures were diagnosed based on

isolates that were from wounds (7%), blood (11%), and from another source (1%). The majority of persons with exposure of a wound to water (86%, 19/23) had their diagnosis confirmed based on wound culture; 9% were based on blood culture and 5% were based on isolates from stool or other specimens. Wounds were also the most common diagnostic sites of persons with swimming exposures (49%, 21/43), who walked in water (54%, 15/28), and who handled or cleaned seafood (47%, 8/17).

In Connecticut, 59% of the *Vibrio* isolates collected between 1999 and 2010 were *V. parahaemolyticus*. The second most common species isolated was *V. alginolyticus* (16%) followed by *V. fluvialis* (8%) (Table 4). Different species accounted for larger percentages of specimens from certain sites. *V. parahaemolyticus* accounted for the largest percentage of isolates from stool (76%, 68/90) and wounds (54%, 27/50), and there were no *V. alginolyticus* or *V.vulnificus* isolates made from a stool source. *V. vulnificus* was responsible for causing 33% (5/15) of the blood infections. Additionally, positive blood and wound specimens were more commonly acquired from those $\geq$ 50 years old (93%, 14/15 and 54%, 27/50, respectively). While there were no positive specimens collected from a wound source during the cold water months, 100% (50/50) of the wound infections occurred during the warm water months. There was no significant difference between specimen source types collected in coastal counties versus non-coastal counties. While the total number of *Vibrio* species increased in incidence significantly over time, the most pronounced increase occurred in the single species, *V. parahaemolyticus* (Table 5).

Symptoms experienced by patients whose *Vibrio* was isolated from stool included predominantly cramps (92%, 56/61), diarrhea (87%, 79/91), and nausea (81%, 42/52) (Table 6). For those whose *Vibrio* was isolated from a wound, muscle pain (31%, 9/29), and fever (19%,

7/36) were the most commonly reported symptoms. Patients with blood infections most commonly reported symptoms of fever (67%, 10/15), diarrhea (40%, 6/15), and nausea (20%, 3/15). A total of 18% (31/166) of patients were reported to have developed cellulitis. Of the 166 patients, 39% had at least one pre-existing condition; heart disease was the most frequently reported 13%, followed by diabetes 8%, and malignancy 7% (Table 7). A few of the reported cases 6% had previous gastric surgery and 5% reported a history of alcoholism. Overall, 66% (110/166) of Connecticut patients reported being treated with antibiotics for their *Vibrio* infections.

DISCUSSION

In this study, *Vibrio* isolates from the state of Connecticut were examined for features of epidemiological relevance and trends in incidence from 1999-2010. Although there was a decrease in the number of reported *Vibrio* cases in 2007, when *Vibrio* became a nationally notifiable disease, nationally reported cases of *Vibrio* infection have generally been increasing at FoodNet sites since 2000 [9]. However, in the state of Connecticut, *Vibrio* incidence has exhibited an increasing trend above that of what is observed nationally. Incidence increased approximately 5-fold over the 12 years, and the number of cases increased in all demographic, geographic, bacteriologic and exposure groups examined. The groups that increased the most, as measured by trends in their proportion of all cases were those with wound infections, who had wound exposure to water or who walked in potentially contaminated water and who did so during the summer and fall warm water months. In Connecticut, vibriosis was most often associated with gastrointestinal infection caused by *V. parahaemolyticus*. However, the percentage of wound infections has increased significantly over time, increasing at a higher rate than other infection sites, most notably-gastrointestinal infection sites. Vibriosis was found to be more common in men, in those over the age of 50 years, in residents of coastal counties, and during summer and fall months. These data support the theory that vibriosis may be increasing in Connecticut as a result of climate changes or changes in behavior among susceptible individuals, including increasing rates of water exposure.

In Connecticut, rates have increased nearly 5-fold while at all FoodNet sites combined incidence rates have only increased 2-fold over the same time period [9, 11]. Vibriosis rates in Connecticut for 2010 were close to 9 per million population whereas the national incidence rate reported for all FoodNet sites was reported to be 4 per million population [9]. In 2010 Florida

reported vibriosis rates higher than the national average at 7 per million population with most cases also occurring in warm water seasons, in coastal counties and among those 65 and older [12]. Although the number of cases in Florida was considerably higher, at 130, the population-based incidence rate was still lower than that of Connecticut [12]. Additionally, vibriosis rates in Florida appear to have been increasing since 2008, and they were on a steady decline for the six-year period of 2003-2008 [12].

Since it is difficult to compare data among different sites due to various surveillance system methodologies, the higher relative incidence may be an artifact of a more sensitive laboratory-based surveillance system in Connecticut (and Florida since 2008) [12]. However, the increasing incidence within Connecticut raises the issue of whether laboratory testing methods might have changed over time, a possibility that was beyond the scope of this paper to explore. On the other hand, *Vibrio* are more common in warmer waters (temperatures > 17°C-20°C) [13]. Therefore, this remarkable increase in incidence may be due to increasing sea surface temperatures and higher concentrations of *Vibrio* in the water. The 2008 Sound Report from the Long Island Sound Study does state that seasonal temperatures measured at the Millstone Power Station in New London, CT have increased over the past 30 years [14]. The 2010 Sound Report states that the temperature has increased 1˚C (1.8˚F) since 1976 according to data collected at the Millstone station [15]. The 2010 Sound Report also mentions an overall increase in the number of warm water species within the sound over the last two decades [14, 15]. Additionally, increasing levels of human activity in potentially contaminated water sources could be contributing to the increasing incidence, especially in cases where wound infection occurs. Perhaps this increase in *Vibrio* incidence is the result of a combination of all of these factors. The State of the Gulf of Maine Report and other studies on climate suggest that climate change may

cause changes in the structure of the microbial community, especially due to changes in water temperature and salinity caused by an increasing frequency of extreme weather events [16]. The State of Maine Report also suggests that human population and coastal development may be contributing to higher levels of effluent and urban runoff, subsequently leading to the increasing incidence of vibriosis [16]. Nutrient levels indirectly affect *Vibrio* concentrations via stimulation of phytoplankton growth and death, which produces an energy source for *Vibrio* growth [16].

In Connecticut, men have a higher level of risk for developing vibriosis than women. These findings are similar to previous reports of non-cholera vibriosis cases in California from 2001-2008 [17]. There are a few important reasons why men may be at a higher risk of developing vibriosis than women. Men may have a higher incidence of vibriosis because men may participate in recreational water activities and eat raw or undercooked seafood more frequently than women [18]. Women also have a greater awareness of food safety risk and better food safety practices, which may decrease their risk of developing foodborne infections [19]. Interestingly, the female hormone estrogen has been found to contribute to this gender specificity, which in some manner provides protection against the lethal *V. vulnificus* endotoxin [20].

People over the age of 50 had the highest risk for developing vibriosis compared to all other age groups in Connecticut throughout the study period. Foodborne illness among the elderly is becoming an increasingly important concern as the number of adults that are sixty-five and older is expected to reach 55 million by the year 2020 in the United States [18]. Thus, the population is aging and as the elderly population increases it is likely that we can expect to see a continued rise in the number of vibriosis cases within this population. Although this age group has a greater awareness of food safety risk and better food safety practices, this age group is

more vulnerable to foodborne illness due to decreased immune function [21]. Older adults may also be more prone to have pre-existing or underlying health conditions that put them at a higher risk for developing infection in general (diabetes, malignancies, heart disease, liver disease, loss of stomach acidity, major surgeries, malnutrition, and diminished physiological capacity, etc.) [22]. In addition to this, these individuals may have more leisure time to spend participating in activities (e.g., fishing) that involve contact with potentially contaminated water sources like the Long Island Sound.

Incidence of vibriosis was higher in coastal counties and increased significantly more than in non-coastal counties over the twelve-year study period. This is not a surprising finding as most cases of vibriosis are reported in coastal states [12, 23]. Additionally, this supports the hypothesis that people who live in closer proximity to the Long Island Sound may visit the water more frequently than those who live farther away from the shore. In addition to this trend, almost all cases of vibriosis occurred in the warm water months during the summer and fall (July-November) supporting the hypothesis that warmer water surface temperatures may be in part to blame for the hike in incidence over the years as warmer water temperatures promote *Vibrio* growth as is seen in *V. cholerae* and may attract more people for recreational purposes [24].

There is a known association between vibriosis and consumption of raw or undercooked seafood. A large number of cases who reported consuming raw seafood had their positive specimens collected from stool, suggesting that raw seafood was the source of their infection. It is unknown whether there is an increased risk of vibriosis because more people are eating raw seafood or if the level of risk associated with this behavior has increased. However, it is of interest that the percentage of all cases with raw seafood exposure and with gastrointestinal infection did not increase while the percentage with wound infections and wound exposure to

water did. It is conceivable that awareness of the risk of getting vibriosis from raw/undercooked seafood is higher than awareness of the risk of getting severe wound infections from water exposures and that the former level of awareness is modulating exposures more than the latter is over time. More environmental monitoring and behavioral studies are needed to investigate this issue further.

Different species appear to be causing a different spectrum of infections (e.g., *V. parahaemolyticus* seems to cause all types of infections, *V. vulnificus* seems to cause only severe bloodstream infections, *V. alginolyticus* causes mainly wound (skin) infections while *V. fluvialis* causes mainly gastrointestinal infections), yet all species are increasing more or less equally in CT. The global increase across species in CT is consistent with the main hypotheses for the overall increase: warmer water means a more hospitable environment for vibrio in general. Thus each person exposed is more likely to encounter *Vibrio,* Also consistent with this hypothesis, there is a higher risk of developing symptomatic infection in warmer weather especially when wounds are exposed to water, and longer seasons mean that more people get exposed.

Limitations

This study was limited by several important factors. First, it is not known if clinical laboratory or provider efforts to detect *Vibrio* have increased over time. If better detection methods have replaced those used in the past, this may have biased the results of the study toward finding more of an increase in vibriosis than there really was. We did not have good information about site of infection, so the site from where the diagnostic isolate (source) was obtained was used as a proxy for the site of infection that was experienced by the patient (assuming wound isolates mean skin infection, stool isolates mean infection of the gastrointestinal tract and blood isolates mean more severe infection from either a gastrointestinal or skin source). If the specimen source incorrectly represented the site of infection, then our results would not represent the true distribution of infection sites. In addition, a number of specimens came from "other" sources and did not contribute to the statistics on site of infection. If these had been able to be classified as skin or gastrointestinal sites, our data might be somewhat different. Another limitation was that we had no denominator data for how many people had each exposure. Therefore, we could not calculate risk from each exposure. Additionally, there is no data on the trends associated with the exposures of interest to know if they are changing over time. Finally, there is no microbiological data on *Vibrio* counts in the Long Island Sound to know if there have been changes over time.

CONCLUSIONS

Vibrio incidence has increased in Connecticut. Vibriosis is more common in older age groups, in males, in residents of coastal counties and during warm weather seasons. This is most likely due to the higher levels of exposure to potentially contaminated water or food among those most at risk. Additionally, an increasing frequency of warmer days during the warm water months may be predisposing people to having more frequent and/or longer exposures to potentially contaminated water.

The increase in cases has been most rapid among persons living in coastal areas, in those with wound infections, during warm water seasons, and in those who walk in potentially contaminated water, especially those with wounds. Again, possible explanations for the relatively faster rate of increase in wound infections include: warmer water temperatures with higher *Vibrio* levels and/or more people spending more time in contact with potentially contaminated water. Additional monitoring and study are needed if we are to succinctly correlate *Vibrio* cases with environmental and exposure data.

RECOMMENDATIONS

The data presented herein reflects the need for continued surveillance in order to understand the increase in incidence of vibriosis in Connecticut. In order to determine if *Vibrio* exposures are increasing as a result of higher bacterial load in the Long Island Sound, more environmental monitoring must take place in order to determine if there is a potential connection between human health and the environment. Further studies are needed in order to determine the frequency of exposures of concern in order to produce risk calculations and to see if risk with any specific type of exposure is changing over time. Prevention-related recommendations include public education efforts that target the populations at highest risk for developing vibriosis (older adults, particularly those with underlying medical conditions, men, those living in coastal counties). Because vibriosis in CT is most often associated with gastrointestinal infection and caused by *V. parahaemolyticus*, posting warning signs about the risks associated with consumption of raw or undercooked shellfish at restaurants and shellfish beds may be useful for educating and advising the public about risk involved with these practices at these locations. Additionally, posting advisories (or having pamphlets) cautioning persons with open wounds to avoid contact with the water because of the risk of developing serious *Vibrio* infection - and those who get cuts in their feet or skin while at the Long Island Sound seashore or while in the Long Island Sound should promptly wash and clean them with soap and water and seek medical attention promptly if they develop signs of infection. However, it has been suggested that these warnings do not reach vulnerable populations [25] and that procedures such as cold/heat shock or irradiation may be more a effective means for reducing pathogen counts in raw shellfish products [26].

There is no indicator for these naturally occurring pathogens and detection of *Vibrio* spp. in the environment has been difficult [27]. Because *Vibrio* growth is stimulated by the availability of nutrients in the water, pollution control and environmental management are important components of infectious disease prevention. There is a great need for interdisciplinary interaction amongst the various health and environmental agencies within the state and across the nation. These collaborations are imperative to the mission of the One Health Initiative and the Healthy People Food Safety Goals for 2020.

REFERENCES

1. Scallan, Elaine., et al. Foodborne Illness Acquired in the United States—Major Pathogens. Emerging Infectious Diseases. Vol. 17, No. 1, January 2011.
2. Daniels, NA, Shafaie, A. A Review of Pathogenic *Vibrio* Infections for Clinicians. Infect Med 17(10):665-685, 2000.
3. Simms, Jennifer N., et al. Environ Health Insights. 2011;5:71-85. Epub 2011 Nov 10.
4. McLaughlin, Joseph B. et al. Outbreak of Vibrio parahaemolyticus Associated with Alaskan Oysters. N Engl J Med.: October 6, 2005; 353:1463–1470.
5. Han, Haihong. et al. Genome plasticity of Vibrio parahaemolyticus: Microevolution of the Pandemic Group. BioMed Central Genomics: November 28. 2008; 9:570.
6. Dechet, Amy M., et al. Nonfoodborne *Vibrio* Infections: An Important Cause of Morbidity and Mortality in the United States, 1997-2006. Clinical Infectious Diseases. 2008; 46:970–6.
7. Mead, PS, Slutsker L, Dietz V, et al. Food-related illness and Death in the United States. Emerging Infectious Disease 1999;5:607–625.
8. Matyas, B. et al. MMWR. Preliminary FoodNet Data on the Incidence of Infection with Pathogens Transmitted Commonly Through Food---10 States, 2009. April 16, 2010. 59(14);418–422.
9. Gilliss, D., et al. MMWR. Vital Signs: Incidence and Trends of Infection with Pathogens Transmitted Commonly Through Food—Foodborne Diseases Active Surveillance Network, 10 U.S. Sites, 1996-2010. June 10, 2011. 60(22);749–755.

10. CT DPH. Annual Town and County Population for Connecticut. http://www.ct.gov/dph/cwp/view.asp?a=3132&q=388156. Accessed on January 28, 2012.
11. Shallow S., et al., MMWR. Preliminary FoodNet Data on the Incidence of Foodborne Illnesses—Selected Sites, United States, 2000. April 06, 2001. 50(13);241-6.
12. Department of Health, Florida, 2010 Florida Morbidity Statistics Report. http://www.doh.state.fl.us/disease_ctrl/epi/Morbidity_Report/2010/diseases/Vibrio.pdf. Accessed April 20, 2012.
13. Morris, GJ. Cholera and Other Types of Vibriosis: A Story of Human Pandemics and Oysters on the Half Shell. Clinical Infectious Diseases, 2003;37: 272-80.
14. The Long Island Sound Study. Sound Health 2008 Report. At http://longislandsoundstudy.net/2008/12/sound-health-2008/. Accessed on April 30, 2012.
15. The Long Island Sound Study. Sound Health 2010. At http://longislandsoundstudy.net/wp-content/uploads/2010/12/SH2010_FIN_lores_singles.pdf. Accessed April 30, 2012.
16. The Gulf of Maine Council on the Marine Environment. State of the Gulf of Maine Report: Microbial Pathogens and Biotoxins, September 2011. http://www.gulfofmaine.org/state-of-the-gulf/docs/microbial-pathogens-and-toxins.pdf. Accessed April 20, 2012.
17. Cummings, Kate et al. CDPH. Epidemiologic Summary of Non-Cholera Vibriosis in California, 2001-2008. http://www.cdph.ca.gov/data/statistics/Documents/vibriosis-episummary.pdf. Accessed April 18, 2012.

18. Altekruse SF, Yang S, Timbo BB, Angulo FJ. A multi-state survey of consumer food-handling and food-consumption practices. Am J Prev Med. 1999;16(3):216–21.

19. Anderson, Amy., et al. Food Safety Perceptions and Practices of Older Adults. Public Health Rep. 2011 Mar-Apr; 126(2): 220–227.

20. Oliver. JD. Wound infections caused by Vibrio vulnificus and other marine bacteria. Epidemiol Infect. 2005 Jun;133(3):383-91.

21. Roy K, Haddix AC, Ikeda RM, Curry CW, Truman I, Thacker SB. Monitoring progress toward CDC's health protection goals: health outcome measures by life stage. Public Health Reports 2009; 124:304-16.

22. Smith, JL. Foodborne Illness in the Elderly. Journal of Food Protection, 1998; 61; 1229–39.

23. CSTE. http://www.cdc.gov/nationalsurveillance/PDFs/CSTEVibrio2009.pdf. Accessed April 19, 2012.

24. Huq, et al. Influence of water temperature, salinity, and pH on survival and growth of toxigenic *Vibrio cholerae* serovar 01 associated with live copepods in laboratory microcosms. Applied and Environmental Microbiology (1984). Volume: 48, Issue: 2, Pages: 420–424.

25. Mouzin E, Mascola L, Tormey MP, Dassey DE. Prevention of *Vibrio vulnificus* infections: assessment of regulatory educational strategies. JAMA 1997; 278:576 – 8.

26. Oliver JD, Kaper JB. Vibrio species. In: Food Microbiology: fundamentals and frontiers. Doyle MP, Beuchat LR, Montville TJ, eds. Washington, DC: American Society for Microbiology, 1997:229 – 64.

27. Janda, MJ, et al., Current Perspectives on the Epidemiology and Pathogenesis of Clinically Significant *Vibrio* spp. Clinical Microbiology Reviews, July 1988; 245-267.

Table 1. Epidemiological and Geographic Features of Vibriosis in CT , 1999-2010 (N=174)

Variable	Frequency (N)	Percent (%)	Incidence per million person-years	Relative Risk	*p-value
Age (years)					
0-9	8	5	1.42	Referent	p≤0.0001
10-19	7	4	1.27	0.89	
20-49	62	36	3.51	2.46	
50+	97	55	8.03	5.63	
Sex					
Female	59	34	2.80	Referent	p≤0.0001
Male	115	66	5.81	2.08	
Race					
Asian	6	3	-	-	-
Black	3	2	-	-	
Unknown	41	24	-	-	
White	124	71	-	-	
Ethnicity					
Hispanic	12	7	-	-	-
Non-Hispanic	103	59	-	-	
Unknown	59	34	-	-	
Race/Ethnicity					
Asian/NonHispanic	6	-	-	-	-
Black/Non-Hispanic	3	-	-	-	
Unknown/Hispanic	10	-	-	-	
Unknown/NonHispanic	1	-	-	-	
Unknown/Unknown	30	-	-	-	
White/Hispanic	2	-	-	-	
White/NonHispanic	93	-	-	-	
White/Unknown	29	-	-	-	
Source					
Stool	90	52	2.20	Referent	-
Wound	50	29	1.22	0.56	
Blood	15	9	0.37	0.17	
Other	19	11	0.46	0.21	
Hospitalization					
Yes	37	21	-	-	-
No	137	79	-	-	
County -Coastal	**132**	**76**	**5.18**	**1.91**	**0.0002**
Middlesex	13	7	6.99		
Fairfield	63	36	5.95	-	
New London	15	9	4.82	-	
New Haven	41	24	4.15	-	
County-NonCoastal	**42**	**24**	**2.72**	**Referent**	**-**
Tolland	6	3	3.67	-	
Litchfield	8	5	3.66	-	
Windham	4	2	3.06	-	
Hartford	24	14	2.33	-	
Season					
Winter	6	3	-	Referent	-
Spring	18	10	-	3.00	
Summer	104	60	-	17.33	
Fall	46	27	-	7.67	
Cold Water	24	14	0.59	Referent	p≤0.0001
Warm Water	150	86	3.67	0.22	
¥ Species					
***p**arahaemolyticus*	103	59	2.52	-	-
alginolyticu	27	16	0.66		
fluvialis	14	8	0.34		
vulnificus	8	5	0.20		
cholerae	8	5	0.20		
other	13	7	0.32		
Year					
1999	6	3	1.83	Referent	p≤0.0001
2000	6	3	1.76	0.96	
2001	9	5	2.63	1.44	
2002	11	6	3.18	1.74	
2003	11	6	3.16	1.73	
2004	10	5	2.85	1.56	
2005	13	7	3.70	2.03	
2006	19	10	5.41	2.96	
2007	16	9	4.57	2.50	
2008	14	8	4.00	2.19	
2009	27	15	7.67	4.20	
2010	32	17	8.95	4.89	
Cumulative	174	100	4.26	-	-

*p-value for trend in proportions, **¥** species missing for one observation

Figure 1.Vibriosis Incidence by Year Using 2000 Census and CT Mid-year Population Estimates

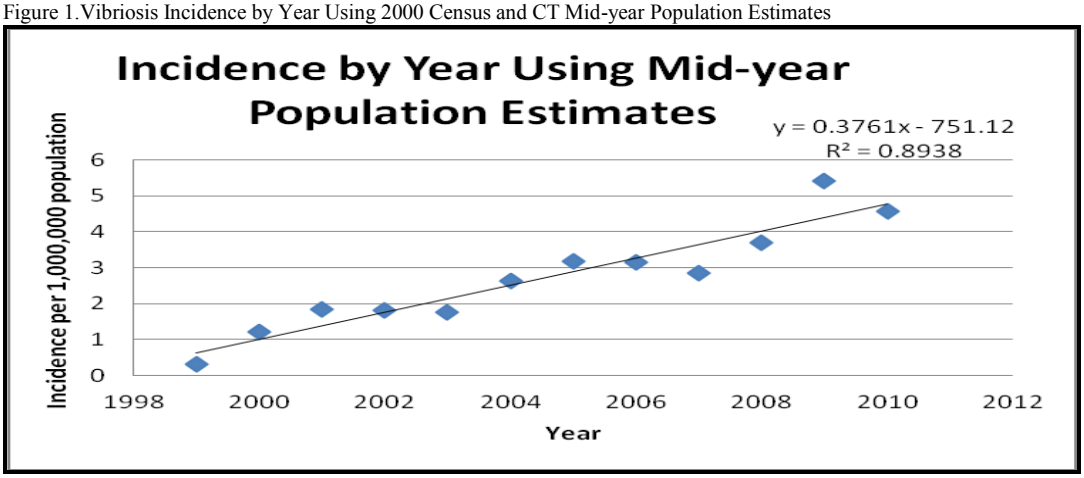

Table 2. Epidemiological, Demographic and Geographic Trends of Vibriosis in CT by Time Period , (N-174)

Variable	Frequency (N)	Percent (%)	Incidence per million person-years	Relative Risk	*p-value
Grouped Years					
1999-2001	21	11	2.05	Referent	p≤0.0001
2002-2004	32	17	3.06	1.49	
2005-2007	48	26	4.56	2.22	
2008-2010	73	39	6.92	3.37	
Age 0-19					
1999-2001	1	7	0.36	Referent	0.02
2002-2004	3	20	1.08	3.00	
2005-2007	3	20	1.08	3.00	
2008-2010	8	53	2.88	8.00	
Age 20-49					
1999-2001	10	16	2.26	Referent	0.03
2002-2004	14	23	3.17	1.40	
2005-2007	16	26	3.62	1.60	
2008-2010	22	35	4.98	2.20	
Age 50+					
1999-2001	10	10	3.31	Referent	p≤0.0001
2002-2004	15	16	4.97	1.60	
2005-2007	29	30	9.60	3.00	
2008-2010	43	44	14.24	4.40	
Male					
1999-2001	15	9	3.03	Referent	-
2002-2004	20	12	4.04	1.33	
2005-2007	28	16	5.66	1.86	
2008-2010	52	29	10.51	3.47	
Female					
1999-2001	6	3	1.14	Referent	-
2002-2004	12	7	2.28	2.00	
2005-2007	20	12	3.80	3.33	
2008-2010	21	12	3.99	3.50	
County-Coastal					
1999-2001	14	8	2.20	Referent	p≤0.0001
2002-2004	23	13	3.62	1.65	
2005-2007	34	20	5.34	2.43	
2008-2010	61	35	9.59	4.36	
County-NonCoastal					
1999-2001	7	4	1.81	Referent	0.17
2002-2004	9	5	2.33	1.28	
2005-2007	14	11	3.63	2.00	
2008-2010	12	7	3.11	1.72	
Cold Water					
1999-2001	5	21	0.49	Referent	0.50
2002-2004	5	21	0.48	0.98	
2005-2007	7	29	0.66	1.36	
2008-2010	7	29	0.66	1.36	
Warm Water					
1999-2001	16	11	1.57	Referent	p≤0.0001
2002-2004	27	18	2.58	1.65	
2005-2007	41	27	3.89	2.48	
2008-2010	66	44	6.25	3.99	
Stool					
1999-2001	12	7	1.18	Referent	0.004
2002-2004	19	11	1.82	1.55	
2005-2007	29	17	2.75	2.34	
2008-2010	30	17	2.85	2.42	
Wound					
1999-2001	5	3	0.49	Referent	p≤0.0001
2002-2004	4	2	0.38	0.78	
2005-2007	13	8	1.23	2.52	
2008-2010	28	16	2.70	5.42	
Blood					
1999-2001	3	2	0.29	Referent	0.31
2002-2004	3	2	0.29	1.00	
2005-2007	3	2	0.29	1.00	
2008-2010	6	3	0.57	1.97	
Other					
1999-2001	1	1	0.10	Referent	0.31
2002-2004	6	3	0.59	5.90	
2005-2007	3	2	0.29	2.90	
2008-2010	9	5	0.88	8.80	

*p-value for time trend

Table 3. Percentage of Interviewed Vibriosis Cases with Selected Possible Exposures to *Vibrio* spp. by Time Period CT, 1996-2010 (COVIS reports, N=166)

Variable	Frequency (N)	Percent (%)	Relative Risk	*p-value
Exposures				
Swimming	**43**	**26**	-	-
1999-2001	5	25	Referent	0.59
2002-2004	8	27	1.14	
2005-2007	8	18	0.65	
2008-2010	22	30	1.32	
Walking in water	**28**	**17**	-	-
1999-2001	1	5	Referent	0.09
2002-2004	6	21	4.96	
2005-2007	4	9	1.85	
2008-2010	17	24	5.87	
Wound Exposure in water	**23**	**14**	-	-
1999-2001	1	5	Referent	0.007
2002-2004	1	3	0.68	
2005-2007	5	11	2.38	
2008-2010	16	22	5.43	
Seafood Drippings (raw or live)	**21**	**13**	-	-
1999-2001	2	10	Referent	0.38
2002-2004	6	21	2.35	
2005-2007	4	9	0.88	
2008-2010	9	13	2.29	
Handling/Cleaning Seafood	**17**	**10**	-	-
1999-2001	2	10	Referent	0.68
2002-2004	3	10	1.04	
2005-2007	3	7	0.64	
2008-2010	9	13	1.29	
Boating	**9**	**5**	-	-
1999-2001	2	10	Referent	0.70
2002-2004	1	3	0.32	
2005-2007	2	4	0.42	
2008-2010	4	6	0.53	
Consuming Any Seafood	**94**	**57**	-	-
1999-2001	11	55	Referent	0.08
2002-2004	20	69	1.82	
2005-2007	31	69	1.81	
2008-2010	32	44	0.65	
Consuming Any Raw Seafood	**57**	**34**	-	-
1999-2001	6	30	Referent	0.34
2002-2004	13	45	1.90	
2005-2007	18	40	1.56	
2008-2010	20	28	0.90	
Comorbidities				
Any Precondition	65	39	-	-
1999-2001	9	45	Referent	0.85
2002-2004	11	38	0.75	
2005-2007	16	36	0.67	
2008-2010	29	40	0.82	

*p-value for time trend

Table 4. Vibriosis Species, Age Group, Season and County by Source of Infection (N=174)*

Species	Stool n (%)	Wound n (%)	Blood n (%)	Other n (%)	Total n (%)	p-value
parahaemolyticus	68 (76%)	27 (54%)	4 (27%)	4 (22%)	103 (59%)	**≤0.0001**
alginolyticus	0 (0%)	18 (36%)	1 (7%)	8 (44%)	27 (15%)	
fluvialis	11 (12%)	0 (0%)	2 (13%)	1 (6%)	14 (8%)	
***cholerae*, non-O1, nonO139**	4 (4%)	1 (2%)	2 (13%)	1 (6%)	8 (5%)	
vulnificus	0 (0%)	3 (6%)	5 (33%)	0 (0%)	8 (5%)	
Other/Unknown *Vibrio* spp.	7 (8%)	1 (2%)	1 (7%)	4 (22%)	13 (7%)	
Total N (%)	90 (52%)	50 (29%)	15 (9%)	18 (10%)	173* (100%)	
Age Group	**Stool n (%)**	**Wound n (%)**	**Blood n (%)**	**Other n (%)**	**Total n**	**0.0002**
0-9	0 (0%)	6 (75%)	0 (0%)	2 (25%)	8	
10-19	2 (29%)	2 (29%)	0 (0%)	3 (43%)	7	
20-49	42 (68%)	15 (24%)	1 (2%)	4 (6%)	62	
50+	46 (47%)	27 (28%)	14 (14%)	10 (10%)	97	
Total	90 (52%)	50 (29%)	15 (9%)	19 (10%)	174 (100%)	
Season	**Stool n (%)**	**Wound n (%)**	**Blood n (%)**	**Other n (%)**	**Total n**	**0.0008**
Cold Water	18 (75%)	0 (0%)	2 (8%)	4 (17%)	24	
Warm Water	72 (48%)	50 (33%)	13 (9%)	15 (10%)	150	
Total N (%)	90 (52%)	50 (29%)	15 (9%)	19 (11%)	174 (100%)	
County	**Stool n (%)**	**Wounds n (%)**	**Blood n (%)**	**Other n (%)**	**Total n**	**0.41**
Coastal	65 (40%)	39 (30%)	11 (8%)	17 (12%)	132	
Non-Coastal	25 (59%)	11 (26%)	4 (10%)	2 (5%)	42	
Total	90 (51%)	50 (29%)	15 (9%)	19 (11%)	174 (100%)	

*Total does not add to 174 due to missing data

Table 5. Reported Vibriosis Cases by Species, Age, Grouped Years by Time Period, CT, 1999-2010 (N=174)*

Species	1999-2001 n (%)	2002-2004 n (%)	2005-2007 n (%)	2008-2010 n (%)	Total n (%)	p-value
parahaemolyticus	13 (62%)	15 (47%)	35 (73%)	40 (56%)	103 (59%)	≤0.0001
alginolyticus	3 (0%)	5 (36%)	5 (7%)	14 (44%)	27 (15%)	0.001
fluvialis	0 (0%)	6 (19%)	1 (2%)	7 (10%)	14 (8%)	0.029
***cholerae*, non-O1, nonO139**	1 (5%)	4 (13%)	1 (2%)	2 (3%)	8 (5%)	0.97
vulnificus	2 (10%)	0 (0%)	2 (4%)	4 (6%)	8 (5%)	0.21
Other/Unknown *Vibrio* spp.	2 (8%)	2 (2%)	4 (7%)	5 (22%)	13 (7%)	0.18
Total n (%)	21 (12%)	32 (19%)	48 (28%)	72 (42%)	173* (100%)	≤0.0001
Age Group						
0-19	1 (4%)	3 (9%)	3 (6%)	8 (11%)	15 (9%)	0.02
20-49	10 (48%)	14 (44%)	16 (33%)	22 (30%)	62 (36%)	0.04
50+	10 (48%)	15 (47%)	29 (61%)	43 (59%)	97 (56%)	≤0.0001
Total	21 (12%)	32 (18%)	48 (28%)	73 (42%)	174 (100%)	≤0.0001

* Total does not add to 174 due to missing data

Table 6. Percent Vibriosis cases by Symptoms and Source, COVIS reports, CT, 1999-2010. (n=166)

Symptoms	Stool	Wound	Blood
Diarrhea	87%	5%	7%
Cramps	92%	2%	3%
Nausea	81%	6%	9%
Fever	50%	19%	28%
Muscle Pain	55%	31%	14%
Headache	78%	9%	3%
Vomiting	82%	6%	12%
Cellulitis	3%	83%	13%

Table 7. Percent Vibriosis cases with Pre-existing Conditions, COVIS Reports CT, 1999-2010. (n=166)

Pre-existing Conditions	Percentage
Heart Disease	13%
Diabetes	8%
Gastric Surgery	6%
Malignancy	7%
Renal Disease	3%
Liver Disease	4%
Alcoholism	5%
Hematologic Disease	3%
Any Pre-existing Condition	39%